

Power System Technology That Changes The Conventional Trend

Progressing Power Conversion Technology for UPS

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1. Introduction

The power system technologies in our company are electric power conversion technology and AC power generation technology. The electric power conversion technology is used in the uninterruptible power supply (hereafter, it is called UPS) and the power conditioner for photovoltaic power generation and it converts the DC power into the AC power or the AC power into the DC electric power. And a technology that generates the AC power is used in the engine power generation devices.

The AC power conversion technology of UPS and electric power conditioner is called a static type that uses the semiconductor, and the engine generator is called a rotation type.

This document classifies the electric power conversion technology of the static type into a main circuit and the control circuit, etc. and introduces the technology that changes the trend about UPS.

2. Main Circuit Technologies And Electric Semiconductor

Technically there is a trend in a main switching element of the AC/DC conversion circuit and the DC/AC conversion circuit.

Though thyristor was used before, a gate turn-off thyristor (hereafter, it is called GTO), a transistor, an insulation gate bipolar transistor (hereafter, it is called IGBT), and a new semiconductor were put to practical use, and the conversion circuit has changed greatly.

2.1 Electric Power Conversion Circuit That Uses Thyristor

The thyristor does not have the self-arc-interruption ability. Therefore, the arc-interruption circuit where the thyristor is interrupted with an external circuit is necessary. In addition, a multiple method was adopted in the DC/AC conversion because it was not able to raise the switching frequency.

Fig.1 shows an example of the electric power conversion circuit that uses thyristor.

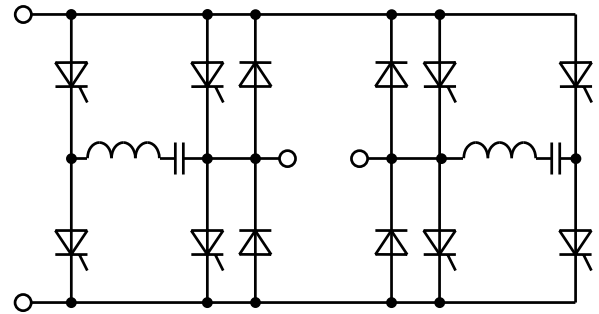


Fig.1 Thyristor Electric Power Conversion Circuit

In this circuit, a large value of the reactor and the capacitor are connected with the output of the converter in parallel, and arc-interruption of the thyristor is done. As above, because the arc-interruption circuit grew large, and conversion method was multiple methods, the thyristor conversion circuit was behind in its characteristics.

2.2 Electric Power Conversion Circuit That Uses GTO

The arc-interruption circuit becomes unnecessary in an electric power conversion circuit, and external size has become small rapidly by putting GTO with the self-arc-interruption ability to practical use. However, the switching frequency could not be enlarged, and the conversion method did not change from the multiple methods. It resulted in no improvement on the characteristic side.

Fig.2 shows the conversion circuit that uses GTO.

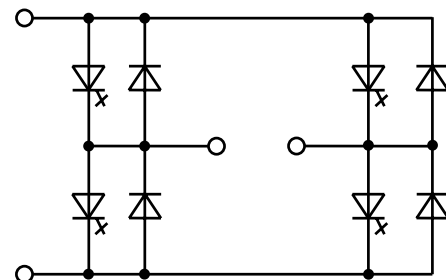


Fig.2 GTO Electric Conversion Circuit

2.3 Electric Power Conversion Circuit That Used Transistor

Because the transistor has the self-arc-interruption ability and the switching loss is small, it can raise the switching frequency. The conversion method shifted from a multiple method to a PWM (pulse-width modulation) method because it was able to enlarge the switching frequency.

Here, a big improvement on the characteristic side was seen.

When the load was a nonlinear in the current with multiple methods, the amends ability of the distortion current was small and not able to connect a nonlinear load with ratings. It is able to connect a nonlinear load with ratings of the device by adopting the PWM method, and the use rate of the device has improved.

Fig.3 shows the waveform of the conversion circuit and PWM.

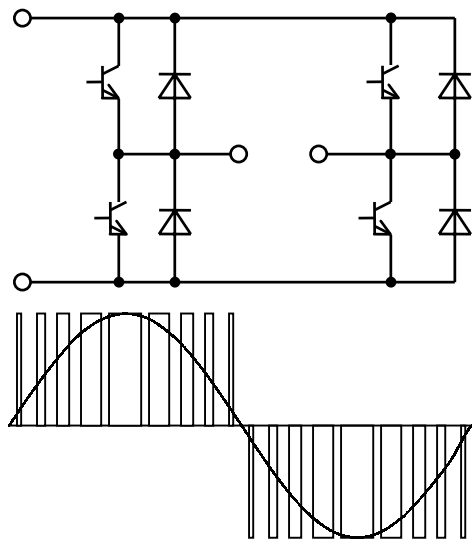


Fig.3 Transistor Electric Conversion Circuit And PWM Wave Form

2.4 Electric Conversion Circuit That Uses IGBT

IGBT is an electric semiconductor that improves the switching performance by one digit or more compared with the transistor, and is the latest element today.

The conversion frequency of PWM can be raised by the great improvement of switching performance. As a result, the AC filter that smoothes the waveforms of PWM becomes small, and it is compact in size and economical. In addition, the switching frequency increased higher than the audio frequency of man, helping to reduce the noise.

2.5 The Future of Main Circuit Technology And Electric Semiconductor

The next promising electric semiconductor of IGBT includes the electric semiconductor that uses carbonization silicon (SiC) as a material.

SiC has a large insulation destruction electric field and thermal conductivity. By making the best use of this char-

acteristic, the semiconductor element of low loss that operates at the high temperature can be realized. If this semiconductor is put to practical use, the efficiency of the power conversion circuit improves greatly. Also the cooling structure becomes small and the miniaturization of the device becomes possible.

Moreover, as the switching speed of the semiconductor rises, the noise emission level increases. As for the main circuit technology in the future, technology that suppresses the noise economically is required along with advancement of the electric semiconductor.

3. Trend Of Control Circuit Technology

3.1 Sequence Control Technology

The relay was used in the sequence control that ruled startup and shutdown of the device that used the power conversion circuit, and the trouble shooting, etc. In the following generation, the digital sequence circuit that used logic IC became the mainstream. Today, the circuit that uses MPU is the mainstream.

By using MPU, more complex operations become possible. MPU also makes it easy to change operation by the usage of the device.

3.2 Power Conversion Control Technology

The control technology that suits the main circuit method introduced in clause 2 is a mainstream technology. Today, PWM control technology is the obvious choice.

The technology improvement is driven by the development of the device used and is also driven by the development of the control circuit technology itself.

The DSP (digital signal processor) changed the trend greatly in accordance with the development of the device used. By putting digital control in the DSP instead of the analog control, the number of parts has decreased. It became compact in size and economical and it also improved in reliability.

MPU, which enables high-speed operation, has been put on the market as a device. As the trend, by using MPU, it makes it possible to include the sequence control in clause 3.1 and the PWM control into one device, and it promotes further miniaturization and being economical

The development of the control circuit itself is another. Specifically, various technologies are proposed in the control technology of the parallel operation of the DC/AC conversion circuit. Our company developed our original, individual control method that may change the trend greatly. This control method is introduced in the following text.

One long time issue was how to reduce the common control part in the parallel operation of the output of the DC/AC conversion circuit. In general, through sensing the cross-flow when operating in parallel, valid and invalid elements of this cross-flow were extracted, and the phase and amplitude control of the output AC waveform was performed. However, because this circuit was complicated, complex adjustment was required to stabilize the control.

When two voltage sources are connected in parallel

through resistance, the current between the voltage sources is suppressed by resistance and balance. It is our original, individual parallel control to discover the technology that gives an equal effect by the control as this resistance nature, and to enable the parallel operation easily. With this technology, the cross-flow and its elements do not have to be extracted anymore. It only requires its own output current to be taken into the control and any complex circuit is not needed, and the parallel control became independent.

Please refer to “Analysis of the parallel operation of UPS that considers the influence of the line resistance,” in our No.10 Technical Report for details.

4. Power System Technology As UPS

The previous text introduced the trend of the main semiconductor, the main conversion circuit, and the control technology etc. in the electric power conversion part to clause 3. Now, the UPS and the UPS system technology that is the main product of our company that uses the power conversion technology will be described.

4.1 Continuous INV Power Supply System UPS And Continuous Commercial Power Supply System UPS

In general, it is a double-conversion system where two conversion circuits of CONV that converts from AC into DC and INV that converts DC into AC are used. And UPS that usually supplies the power by INV is a main current.

Also the continuous commercial UPS has been produced that usually supplies the power from the commercial and from the INV when blacking out. Though this usually is an efficient device to supply power from the commercial, when blacking out, it needs time to switch to power supply from the INV and it is necessary to limit the load.

In recent years, a lot of technologies that make the best use of the advantage of the INV UPS and the commercial UPS of the double-conversion system have been developed and the selection range for users has been extended.

Moreover, a new technology has been developed regarding the high-reliability of UPS where the parallel redundant system or the common spare system is general.

The following section introduces the technology that changes the trend of UPS.

4.2 Parallel Processing System UPS

In the parallel processing UPS, it always operates in parallel with the commercial. When blacking out, the commercial is separated from the INV and power supply is shifted to the INV without momentary power breaks. Because the load does not need to be limited by any momentary power breaks when blacking out and power was supplied from the commercial, a highly effective device could be achieved. Moreover, it has the active filter function that does not drain out the harmonic current generated when the load is nonlinear to the commercial power supply side.

Fig.4 shows the block chart of the basic circuit.

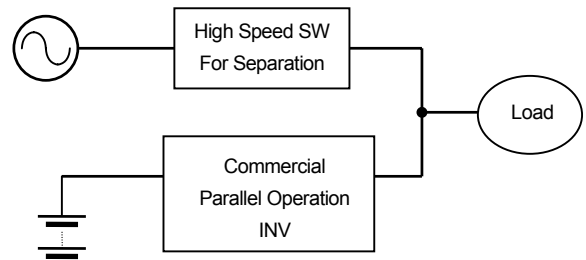


Fig. 4 Block Chart of the Basic Circuit

Our company produces the mid-scale model of 20kVA to 200kVA. Please refer to “Development of Mid-scale UPS ‘SANUPS E” in our No.14 Technical Report for details.

4.3 Continuous INV Power Supply UPS With I/O Common Circuit

Combining an AC/DC conversion circuit, a DC/AC conversion circuit and a continuous INV power supply, the UPS technology allows the conversion part for one line of the input and that of the output to become a common circuit. It not only becomes economical with the I/O common circuit but also it has the following feature.

In this method, only the current that flows to a common circuit is the harmonic current of the load when the phase of the input voltage and the output voltage meet, and the current that flows to the semiconductor element decreases. Moreover, the voltage of DC can be set low, and the switching loss of the semiconductor element can be suppressed. By these two effects, efficiency rose greatly compared with the general continuous INV power supply UPS.

It is called three-arm system for the I/O single phase. Fig.5 shows the circuit of single-phase 3-arm system.

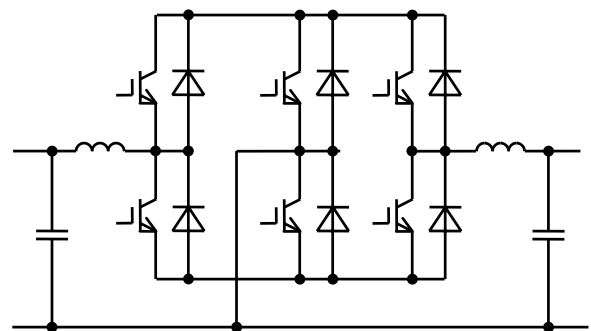


Fig.5 Circuit of Single Phase 3-Arm System

Our company produces the 1kVA single phase I/O model. Please refer to “Development of small-scale UPS ‘SANUPS ASE” in our No.12 Technical Report for details.

4.4 Delta Conversion System UPS

The UPS of the delta conversion system has one DC/AC conversion circuit, and inserts a conversion circuit between the DC/AC conversion circuit and the commercial power that compensates the voltage difference between the input and the output voltage. Fig.6 shows the block chart of the basic circuit. The capacity of the conversion circuit that compensates the voltage can be small and the loss there also becomes small. With this technology, compact, economical and highly effective device can be achieved.

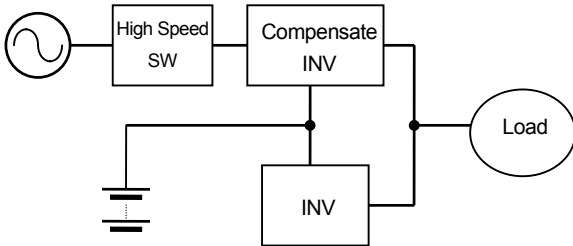


Fig.6 Block Chart of the Basic Circuit

4.5 Unit Common Spare System UPS

The unit common spare system UPS is a new technology with high-reliability. This is the continuous INV UPS that possesses a AC/DC conversion circuit (CONV unit), a DC/AC conversion circuit (INV unit), and a spare conversion circuit (spare unit) that converts AC/DC DC/AC interactively.

When two devices were put respectively and one device broke down, the device of the remainder continued to supply power from the INV. This is how high reliability of the supply power from the INV was raised.

Because the failure rate of the conversion circuit and the control circuit occupy a high portion of the total failure rate, by making this conversion circuit double and using the AC/DC conversion circuit and the DC/AC conversion circuit combined, a small and economical high trust UPS can be achieved. Fig.7 shows the block chart of the basic circuit.

When the INV breaks down or this is maintained, the spare unit is converted in DC/AC, and the power supply is switched from the INV unit without momentary power breaks, and power supply by the INV is continued. Moreover, when the CONV breaks down or this is maintained, the spare unit is converted in AC/DC, and power supply from the INV is continued without using a battery.

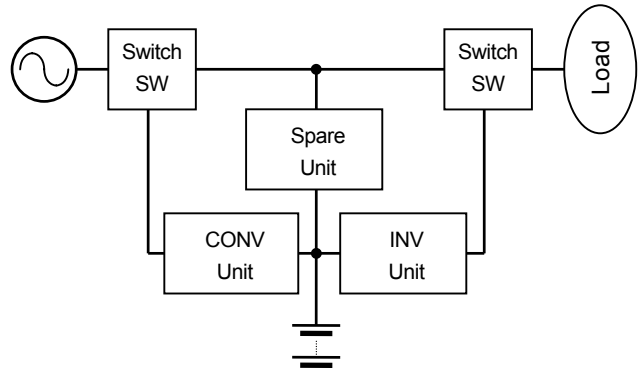


Fig.7 Block Chart of the Common Spare Unit System

5. Conclusion

What changes the trend of the power system is the appearance of excellent devices such as electric semiconductors, ICs, and microcomputers etc. and the technology that utilizes them. Moreover, in the trend of the electric power conversion circuit technology, the basic technique of the electric power conversion circuit is often proposed in early days. Therefore, technology to utilize the basic technology has been developed. The power system technology of UPS includes the advancement of the above-mentioned device, the circuit technology and the composition technology how to use the power conversion circuit.

This document introduced the technology that changes the trend in each part, but the power system technology is polysemous and only one example was introduced here.

The technological progress quickens every year and the change in the trend of the power system technology is not an exception. Continuous efforts will be made to develop the leading technology while reading the trend ahead.



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Joined company in 1980
Power Systems Division, 1st Design Dept.
Worked in development and design of the static type power supply system